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Formulation and nutrient composition of dry season rations for ruminants using crop residues and their rumen degradation characteristics in semi-arid region of Nigeria

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ABSTRACT

An experiment was conducted to evaluate four (4) different locally available feedstuffs, two energy source (cowpea husk and dusa-mixture of brans) and two protein source (poultry litter and groundnut haulms) at different levels of inclusion to formulate nine (9) diets (F1 – F9) to serve as dry season supplement for ruminants. The proximate analysis of these ingredients revealed that blending different ingredients can efficiently meet the requirement of ruminants during the long dry season in semi arid region. While rumen degradation study of the diets was carried out at 6, 12, 18,24,36,48 and 72 hours of incubation to determine the degradability of the diets and the overall result shows that all the formulations recorded above 60 %DM degradability at 48 h period of incubation except F4 with 48.58% with no significant (P>0.05) between F1, F2, F3, F5, F6, F7, F8 and F9.The mean values for the potential degradation of the dry rations were generally high and vary significantly (p<0.05) among all the formulations with a range of 71.53% to 80.97% at 72h. The analysis of cost of producing the formulations shows that F4 has the highest ₦ 3,200 (about $19.39) while F6 had the least ₦ 2,675 (about $16.21) which is affordable to both small scale ruminant owners as well as nomads.

Key words: Degradation, Dry rations, Energy sources, feedstuff, Protein sources, Ruminants

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INTRODUCTION

The estimated ruminant population in Nigeria has been put at 13.9 million cattle forming 60% of the livestock population, 34.5 million goats, 22.0 million sheep (both accounting for 38.5% of the total population of the worlds small ruminants) RIMS(1992). However, most of the livestock species particularly the ruminants in pastoral and extensive mixed production system in most developing countries and Nigeria in particular suffer from permanent or seasonal nutritional stress which can lead to death of young calves, kids or lambs, reproductive inefficiency, low milk yield and short lactations in cows, low weight and poor quality of carcass in animals meant for slaughter. Inadequacies in feeding and nutrition are a major limitation to successful livestock production in Nigeria and sub-Saharan Africa. The problem is more severe during dry season in the semi-arid region where forages become scarce and deteriorate in nutritive quality. One of the possible ways to overcome scarcity of feed during the dry season in semi-arid region and to manage these ruminants on a maintenance ration is to provide supplementation in form of sole or mixtures of crop residues, agro-industrial by product and farm animal wastes(poultry litter, animal faeces, blood, bones etc) that cannot be consumed by man but can be utilized by ruminants when fed such into desirable human food like meat and milk which in turn reduce the cost of production while maintaining steady productivity during the dry season (Odeyinka,2001). Crop residues, agro-industrial by products and animal wastes play a significant role in ruminant nutrition and have been estimated to account for about 25% of the total feed energy suitable for ruminants in both developed and developing countries (Kossila, 1985). Hence, it is necessary to develop economical rations using local feed ingredients which are readily available, determine their nutritional content when combined to form a ration, and their degradation characteristics to evaluate their efficient utilization by ruminant animals.

MATERIALS AND METHODS

Experimental Site

This experiment was carried out at the Livestock unit of the University of Maiduguri Teaching Research Farm, Maiduguri, Borno State. The area falls within the Sahel (semi-arid) region of West Africa, which is noted for its great climate and seasonal variation. It has very short period (3-4 months) of rainfall giving 645.9mm/annum with a long dry period/season of about 8-9 months.

Sample collection and preparation

Four (4) ingredients were used in this study, two energy source (cowpea husk and dusa) and two protein sources (groundnut haulms and poultry litter). Cowpea husk and groundnut haulms were purchased at livestock feed mini market along Lagos street Maiduguri; dusa (mixture of bran) was purchased at a milling store at Maiduguri Monday Market while poultry litter was collected from the poultry unit of university of Maiduguri livestock teaching and research farm. The poultry was sieved to remove unwanted material and is properly stored after sun drying in order to destroy some pathogenic microorganisms like E. coli and salmonella as suggested by (Mohammed *et al.*, 2007).

Feed formulation

The compounding of the ingredients was done based on the 60:40 (energy:protein) principle of feeding ruminants. Nine (9) different rations were formulated using the four ingredients at varying levels of inclusion. After weighing each ingredient using a measuring scale to thorough mixing was done until a homogenous mixture was obtained. A sample of each ration was collected for both proximate analysis and rumen degradation study.

Management of Experimental Bull

The rumen degradation study was conducted at the university of Maiduguri livestock teaching and research farm using a cross bred bull fitted with a rumen cannula of 40mm diameter. Cowpea husk was fed to the bull ad-libitum as the basel diet supplemented with 500g/day of mixture of maize bran and cotton seed cake at 8:30am and 4:30pm.

Rumen Degradation Study

Feed samples from each block were collected, oven dried and ground to pass through 2.5 mm screen. The nylon bags with mesh size of 45 µ and 140 x 90 mm size were used. Five grams (5 g) of the feed samples were weighed in replicates and put into the bags for incubation at 6, 12, 18, 24, 36, 48 and 72 hours. The nylon bags containing the samples were tied at the neck, attached to an undegradable string and tightened to avoid falling during turning and removal from the rumen. Bags were withdrawn by method of sequential addition (Osuji *et al.*, 2000). The bags containing undigested residues were removed from the rumen after each incubation period and washed thoroughly in running tap water until the washing water is clear. The bags with the contents were dried in an oven at 60°C for 48 hours to constant weight to determine the amount of dry matter loss degraded in the rumen. Similarly, the difference in organic matter weight before and after incubation was equivalent to dry matter degraded in the rumen (Orskov *et al.*, 1980; McDonald, 1981).

Washing Loss

Soluble portion of the feed was determined by weighing 5 g of the feed samples into nylon bags in replicates. It was soaked in warm water at 40 °C for one hour, removed and washed under a running tap for 15 minutes in two circles till clear water was obtained. The bags were oven dried at 60 °C for 48 hours to constant weight (Orskov *et al.*, 1980).

Chemical analysis
Feed samples were analyzed for Dry Matter (DM), Crude Protein (CP), Crude Fiber (CF) and Ash using the methods of AOAC (1999).

Statistical Analysis
Data collected were subjected to analysis of variance (Steel and Torrie, 1980). Significant differences between means were tested using LSD.

Cost of Ration Production
The cost of producing a 100kg of each of the nine (9) rations was determined in Nigerian Naira (₦) when a USD $1 is equivalent to ₦165. The cost incurred in this experiment ranged from ₦ 2,675 – ₦ 3,130 equivalent to $16.22 - $18.97 respectively.

RESULTS AND DISCUSSION

Table1: Feed Formulation based on 100kg

Ingredients	F1	F2	F3	F4	F5	F6	F7	F8	F9
Cowpea husk	40	50	35	45	25	20	15	50	10
Dusa(Bran)	20	10	25	15	35	40	45	10	50
Groundnut haulms	30	25	35	15	10	25	15	20	25
Poultry liter	10	15	5	25	30	15	25	20	15
Total(kg/%)	100	100	100	100	100	100	100	100	100

F1-F10= formulations

Table 1 shows the proportion of each ingredient in the nine (9) rations developed for the study using cowpea husk, groundnut haulms, dusa (bran) and poultry litter at varying levels of inclusion. Maximum inclusion level of cowpea husk, dusa (bran), groundnut haulms, and Poultry litter was 50%, 50%, 35%, and 25% respectively. The level of inclusion of cowpea husk is below the 60% inclusion level recommended by (Adeloye, 1995) which can serve as an efficient fattening ration and dry season feed for ruminants. Poultry litter had up to 30% inclusion level in F6 which is slightly above the 20% inclusion level suggested by (Malgwi and Mohammed, 2015) but in agreement with 30% inclusion (Bhattachaya and Taylor, 1975) reported who observed that in feeding growing heifers, lactating cows, goats and fattening calves using poultry litter at 30% level of inclusion yielded a better performance. The inclusion level of dusa (bran) in this experiment ranged from 10 – 50% which is slightly different from 10 – 26% inclusion level used in (Malgwi and Mohammed 2015)

Table 2: Proximate composition of ingredients

Ingredients	%DM	%CP	%CF	%EE	%Ash	%NFE	GE MJ/KgDM
Groundnut haulms	91.00	10.90	31.80	1.31	8.30	52.90	13.80
Dusa(Bran)	95.91	5.89	14.56	1.80	5.13	64.20	14.64
Poultry	95.50	14.00	20.00	5.00	6.08	50.50	12.89
Cowpea husk	80.70	6.59	9.40	1.40	9.80	50.70	14.80

DM-dry matter, CP- crude protein, CF- crude fiber, EE- ether extract, NFE- nitrogen free extract and GE- gross energy.

Table 2 presents the proximate composition of the ingredients used in the formulations which ranged from 80.70 - 95.51 %DM, 5.89 - 10.90 %CP, 9.40 - 31.80 %CF, 1.31- 5.00 %EE, 5.13 – 9.80%Ash, 50.50 – 64.20 %NFE and 12.89 – 14.80 %GE. The %DM content in this experiment was not in agreement with what was reported by (Kinfemi *et al.*, 2009) who recorded 90.83 %DM for cowpea husk but higher than 93.6 %DM and 92.6 %DM reported by of (Bogoro *et al.*, 1994; Oyenuga, 1978) respectively while that of bran is higher than 89.0 %DM reported by (Mlay *et al*., 2001) but groundnut haulms recorded %DM in concord with 90.00 - 92.90 %DM range reported by (Reddy *et al.*, 1985). The nutritional composition of these crop residues vary basically due to series of interrelated factors which interact and alters nutrient value of crop residues. These factors include differences in species, crop variety, environmental conditions, and age at harvest as well as storage method.

Table3: Proximate composition of the formulations

Formulation	%DM	%CP	%EE	%CF	%ASH	%NFE	GE(MJ/KgDM)
F1	97.30	5.60	5.00	24.00	15.00	49.60	2.43
F2	97.30	5.77	7.00	23.00	12.00	47.77	2.47
F3	97.20	5.95	8.00	25.00	17.00	55.95	2.82
F4	97.50	6.82	2.00	25.00	11.00	44.82	2.19
F5	97.30	6.12	9.00	34.00	14.00	63.12	3.32
F6	97.80	4.37	2.00	34.00	11.00	51.37	2.54
F7	97.40	6.12	7.00	23.00	18.00	54.12	2.66
F8	97.40	4.90	5.00	20.00	6.00	35.90	1.95
F9	97.30	8.05	10.00	17.00	10.00	45.10	2.50

F1-F10- formulations, DM-dry matter, CP- crude protein, EE-Ether extract, CF- crude fibre, NFE- nitrogen free extract.

Table 3 shows the proximate composition (crude protein, dry matter, crude fiber, ash, ether extract, nitrogen free extract and energy content) of the ten (10) different diets formulated in this experiment. The %DM ranged from 96.8 - 97.8 %DM and this range is lower than 98.30 to 99.90 %DM reported by (Malgwi and Mohammed, 2015) who used similar ingredients. The %CP, %CF, %EE, %Ash, and %NFE ranged from 4.37 - 8.05 %CP, 17 - 34%CF, 2.00 - 10.00 %EE, 6.00 - 18.00 %Ash, and 35.90 - 63.12 %NFE respectively while the Gross energy is between 1.95 - 3.32MJ/kgDM which is lower than 3.61-3.94MJ/kgDM reported by (Malgwi and Mohammed 2015).

Table 4: Percentage dry matter degradability (%)

Formulations	6	12	18	24	36	48	72
F1	28.23^{b}	33.85^{b}	44.76^{a}	56.79^{a}	64.29^{c}	72.46^{a}	75.85^{c}
F2	33.10^{a}	27.65^{d}	39.24^{a}	59.04^{a}	67.06^{a}	69.97^{a}	75.59^{d}
F3	37.97^{b}	39.38^{a}	33.51^{d}	43.92^{c}	60.06^{e}	69.26^{a}	71.53^{f}
F4	32.76^{b}	34.14^{b}	44.31^{a}	58.97^{a}	67.92^{a}	48.58^{b}	78.10^{b}
F5	31.18^{b}	36.77^{a}	50.53^{a}	58.81^{a}	70.69^{a}	75.26^{a}	76.95^{b}
F6	26.09^{c}	32.54^{c}	36.11^{c}	51.02^{b}	62.50^{d}	69.52^{a}	77.52^{b}
F7	31.09^{b}	35.95^{b}	51.28^{a}	58.95^{a}	65.08^{b}	68.66^{a}	75.98^{c}
F8	28.55^{b}	31.76^{c}	37.50^{b}	35.14^{d}	55.58^{f}	73.48^{a}	73.48^{e}
F9	25.22^{d}	34.29^{b}	38.88^{b}	57.81^{a}	69.81^{a}	78.05^{a}	80.97^{a}
SEM	1.71	2.02	4.64	1.36	1.61	7.71	0.78

$^{a, b, c,}$ *=Means in the same row bearing different superscript are significantly different (p < 0.05).*

Table 4, gives the dry matter degradability pattern of all the ten formulations which ranged from 25.22 – 37.97%, 27.65 – 39.38%, 33.51 – 51.28%, 31.54 – 59.04%, 55.58 – 75.26%, 73.78 – 80.97% at 6, 12, 18, 24, 36, 48 and 72 hours respectively. However, the mean degradability values observed for all the formulations at 48 hour of incubation period are higher than the minimum of 60% recommended (Smith *et al.*, 1988) cited in (Malgwi and Mohammed, 2015) and could be considered as a good ration for ruminants except for F4 that record 48.58% which could be due to its fibrous nature and thus will require a longer resident time in the rumen. At 6, 12, 18 and 24 hours all the formulations vary significantly (P<0.05) in percentage dry matter degradability. There is no significant (P>0.05) amongst F1, F3, F4, F5, F7 and F8 at 6 hours of incubation. Highest degradability at 18, 24 and 36 hours of incubation was recorded in F7, F2, and F9 with 51.28%, 59.04%, and 69.81% respectively. This degradation pattern is slightly different from 36.60 – 76.40% range recorded for multinutrient blocks in (Zara *et al.*, 2014) using similar ingredients after 24 hours of incubation. At 36, no significant (P>0.05) was observed amongst F2, F4, F5 and F7 but significant (P<0.05) variation in degradability exist between F1, F3, F6, F8 and F9. Significant (P<0.05) variations in degradation was observed between F4 and all the other formulations at 48 hours, thus, highest degradation was recorded in F9 with 78.05% and this could be due to its high protein and low fiber content. High concentration of fibrous ingredients and the insoluble degradable fraction of some of the rations could affect rate of degradation of a feed (MacDonald *et al.*, 1995; Oni *et al.*, 2008) and this in addition to the variation in ingredients used in the formulations is the major reason for this degradation pattern. Actual rumen degradation is dependent on resident time of a feed in the rumen and is also a function of the proximate composition of the feed as stated by (Reddy, 2001), hence, after 72 hours of incubation, the degradation is said to be complete as revealed by the degradability pattern and highest degradability was recorded in F9 with 80.97% similar to 82.60% and 82.67% reported by (Zarah *et al.*, 2014; Malgwi and Mohammed, 2015). High degradation of F9 in addition to its good protein content and low fiber content could be due to it moderate gross energy content of about 2.50MJ/KgDM.

Table 5: Cost of formulations (₦/per 100kg)

Formulations	Cowpea husk	Bran(Dusa)	Groundnut haulms	Poultry litter	Total(₦)
F1	1240	520	1170	200	3130
F2	930	780	780	400	2890
F3	1550	260	975	300	3085
F4	1085	650	1365	100	3200
F5	1395	390	585	500	2870
F6	775	910	390	600	2675
F7	620	1040	975	300	2935
F8	465	1170	585	500	2720
F9	1550	260	780	400	2990
F10	310	1300	975	300	2885

USD $1 = ₦165

Table 5 shows the cost of producing a 100kg of each formulation determined in Nigerian Naira (₦) when a USD $1 = ₦165. This cost incurred in this experiment ranged from ₦ 2,675 – ₦ 3,130 equivalent to $16.22 - $18.97 respectively. This is similar to (Ibrahim *et al.*, 2012) who recorded high cost of production of 100kg of a ration at ₦ 2,522 - ₦ 2, 835 ($16.27 - $18.29) but different from the range of ₦2710 - ₦7600/100kg ($17.48 - $49.0) incurred by (Malgwi and Mohammed, 2015). This variation in production cost is attributed to the prevailing market prices of the ingredients, type and quantity of ingredients, inclusion level of the ingredients and availability of the ingredients used in the production of the rations. However, this experiment shows that blending crop residues to produce least cost rations for ruminants is more economical in terms of cost and nutritional advantage to animals fed such mixed rations.

CONCLUSION

From the results of this experiment, it is therefore concluded that mixing different crop residues is economical and more nutritious in producing rations using local feed ingredients which are readily available for utilization by agro-pastoral in ruminant feeding, thus, reducing production cost and increasing feed quality. Also, up to 15 - 30% level of inclusion for poultry litter can be utilized in providing protein in ruminant diet with maximum care given to its preparation.

Recommendations

It is recommended that based on the findings of this study that crop residues should not be fed as a sole feed but rather in combination with two or more crop by products in order to raise the nutritional status of the feed at a very cheap and affordable cost. Also F9 with moderate (affordable) production cost and highest degradability at 36, 48 and 72 hours containing 10% cowpea husk, 50% dusa (bran), 25% groundnut haulms and 15% poultry litter can result in significant improvement in livestock production.

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